BASCOM

Design of a Septic Tank

Mun. & San. Engineering
B. S.
1905

UNIVERSITY
OF
ILL. LIBRARY

UNIVERSITY OF ILLINOIS
LIBRARY

Class 1905 Book B29 Volume

Je 05-10M

The person charging this material is responsible for its return to the library from which it was withdrawn on or before the **Latest Date** stamped below.

Theft, mutilation, and underlining of books are reasons for disciplinary action and may result in dismissal from the University.

UNIVERSITY OF ILLINOIS LIBRARY AT URBANA-CHAMPAIGN

BUILDING USE ONLY

L161—O-1096

409
B57 U48

THE DESIGN

OF A

SEPTIC TANK

BY

GEORGE ROCKWELL BASCOM

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

MUNICIPAL AND SANITARY ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1905

1905
B29

UNIVERSITY OF ILLINOIS

May 26, 1905

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

GEORGE ROCKWELL BASCOM

ENTITLED THE DESIGN OF A SEPTIC TANK

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Municipal and Sanitary Engineering

A. N. Talbot

HEAD OF DEPARTMENT OF Municipal and Sanitary Engineering

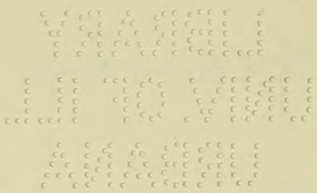
75339

The Design of a Septic Tank.

The purpose of this thesis is to illustrate the essential features to be taken into consideration in the design of a septic tank - not to discuss the advisability of using such a process in sewage purification. In order to facilitate matters a specific case will be taken, and the design made to cover local conditions.

Discussions of the different controlling features, such as capacity, depth, velocity, etc., will be given and conclusions drawn.

The city chosen for the design and study is Champaign, Illinois, a town of about 12000 inhabitants. In general the conditions of inland towns of the Middle West, when hard water is used, will be similar to those of Champaign, and although the cases may not be exactly parallel, the design will be much the same.



Digitized by the Internet Archive
in 2013

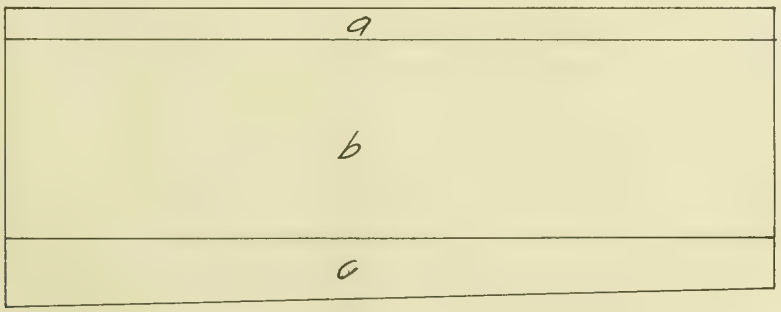
http://archive.org/details/designofsepticta00basc

The septic tank process for sewage purification is of rather recent origin, and for this reason there is still room for much study and improvement of the details. In fact it cannot be said that this process is the ideal method of sewage purification, simply because the conditions vary so much, but it is a conservative statement that this process is very effective as a means of preliminary treatment. Some interesting tests can be made on sewage by subjecting it to the septic tank process. The experiments are conducted so as to show the amount of purification taking place in the tank and its effect on the secondary purification processes. As is commonly understood, the septic tank is merely a modern cesspool, built in box like form in the ground ordinarily, through which the sewage flows at very low velocities, and in which, through the agencies of bacteria and of sedimentation, a purification and liquefaction is

carried on. Now the real office of a septic tank is to reduce the organic matter which are in suspension, and not as many might be led to suppose, to completely purify the sewage. Originally the idea of the tank was that of a settling tank, a name which clings to septic tanks today, into which the sewage was discharged and from which it was discharged at such low velocities that the matters in suspension would have a chance to settle, thus leaving a comparatively clear effluent to be acted upon, in turn, by some suitable secondary process of purification. This action of course takes place in the septic tank, but it was soon discovered, however, that a further action was found on at the same time, and this of a secondary nature. This action tended further to reduce the suspended matter, and now constitutes that part of the sewage purification process known as the primary or anaerobic process.

When this fact was first brought before the world the Inventors of the septic tank seemed to the writer almost undimmed in the dawn of Sewage purification. Here was another door-knob to the whole task so obvious and simple it seemed a wonder it had not been discovered hundreds of years ago in the catacombs. Were not Adam's descendants dicing from residing to Velsite and from Adamus etc.. It is not difficult to design the tank & that a uniform action will take place in the sewage for a part of the sewage may remain in the tank not more than six hours. A gas bladder is created just in connection with the tank through which the sewage first passes. It is there that the large particles settle & float. Of course the solid part of the sewage and sediment will have to be taken out of the septic tank later and here some arrangement for cleaning is usually provided. When the secluded matter settles the tank

it first tends to rise to the surface due to the effervescent action of the solution. It is here in zone (a) of figure below, that the bacterial action is most rapid and concentrated although it takes place more or less throughout the entire tank. A thick scum forms at this place and acts as a covering for the tank — a very essential feature in the anaerobic process. This scum is black and spongy and is some where from three inches to one foot thick, depending of course on the nature of the sewage, and length of time between cleanings. The zone (b) represents the space in which the current for the most part is toward the effluent weir, and zone (c) is the muddy sediment which collects at the bottom. This latter averages about ten per cent of the capacity of the tank per annum.



In a great many cases, the effluent is disposed of by merely discharging it into the nearest adjoining stream. This method is applicable when the effluent is such a small portion of the flow of the stream that it will not pollute the water for any of the uses to which it is being put. If the stream is being used, at some point below, as a source of water supply, then the amount of effluent must needs be a small part of the minimum flow of the stream. But on the other hand if the stream is not used for any such purpose, the controlling restriction so that the effluent will not, through its possible unsanitary condition, impair the health of those living near by - even though the people do not use the water for drinking purposes. Trouble has often arisen in that cattle will not drink from a stream into which strong effluent is running. This also must be avoided when the stream is used as a source of water supply for cattle, etc..

General Requirements.

Capacity.

As applied to septic tanks, the term capacity has been misused so often that it may be well here to state its proper meaning. Capacity in the above sense is the cubic capacity of the tank in hours flow of sewage. Assumptions have been made by some engineers that the time required for the sewage to pass through a tank is the same as that required to fill a tank of this size, which assertion, of course, is erroneous, since the flow is not uniform throughout the depth of the tank. Experiments at Andover, Mass. showed clearly that with a 4 hrs capacity the results in the secondary treatment were only fair, while those of a 20 hrs capacity were very poor. Some sort of aeration is necessary when the sewage remains too long in the tank and becomes stale. In the tank at Champaign, which is known for its high velocity, as much as 80 to 90 per cent of the total

organic matter, as represented by albuminoid ammonia, by oxygen consumed, and by the total organic nitrogen, is, under favorable conditions, removed. It is to this capacity is best.

Depth –

The question of the best depth for a tank is not such a vital one, yet it is more or less of economic interest. Most tanks have been built about 8 or 9 feet deep, according to the tastes of the designers. It is the writers belief that such depths are sufficient, and anything above to it only adds to the cost of construction. Small tanks may well be built shallower, even four to six ft. deep if the proper velocity can be maintained by so doing.

Relation of Length to Width of Tank.

The most economical form for a septic tank unfortunately is not the same as the one which gives the best uniform flow throughout. The latter form would be a tank whose length is about 2 or 3 times its width, but as this is a rather expensive form of construction it is rarely used

Open vs. Closed Tanks.

Originally the main purpose of the covered tank was considered as being a means of excluding air and light, but recent experiments show that, with proper conditions as regards temperature, the septic action is practically as efficient in an open tank as in a closed tank, due to the fact that the coating which soon forms at the surface acts as a covering. It may be said, however, in favor of the closed tank, that the open tanks in use which have been successfully operated are in countries where the sun is, for the most part, cloudy. The question has resolved itself into this: Is the temperature of the locality in which the tank is to be constructed such that no covering will be needed.[2] This, of course, can only be decided for each specific case in hand.

Temperature.

The question of sewage temperature for best results in the septic process is a very vital one, as has been intimated in the discussion of Covers for tanks. If the temperature of the sewage is high a strong putrefactive action takes place, accompanied by bad odors; on the other hand if the temperature is too low, the bacterial and chemical actions are retarded. The most desirable temperature for sewage in the tank is from 55° to 62° Fahr. - anything above or below this is undesirable.

Out flow.-

The Cameron Septic Tank Co. have patents covering the so-called sub-merged collecting device by which the flow from the septic tank is regulated. The advantage of this form being that the scum at the surface is not disturbed nor carried out with the clear effluent. By substituting a floating baffle as shown

on Fig. 1 State a, this slime can be done away with. The topple holds the sludge back until the heavy effluent does round and over the weir into the collecting tower. This has been made in bricks at the end of the tank. This being a sunken outdoor, but unless this an door. This am not apt to become clogged, and has cause much trouble. The collecting tower shown can be made, and it is advisable to do so here, in the concrete tank. A 2" pipe will be placed at the end of this tower, and will carry the effluent to the land. It seemed best to the writer to round the edge of the collecting tank, as it was a cost saving of cement for, on the edge.

Patients.

Some of the More Important Claims of the Cameron Company.

1. The process of purifying sewage which consists in subjecting sewage under exclusion of air, of light and of agitation to the action of anaerobic bacteria until the whole mass of solid organic matter contained therein becomes liquified, and then subjecting the liquid effluent to air and light.

2. The process of liquifying the solid matter contained in sewage, which consists in seeding a tank of sewage having a non-disturbing inflow and outflow, from light, air and agitation until a mass of micro-organisms has been created of a character and quantity sufficient to liquify the solid matter of the flowing sewage, the inflow serving to sustain the micro-organisms, and then subjecting said tank under exclusion of light and air and under a non-disturbing inflow and outflow and under exclusion of light and air to the liquifying action of the so-cultivated micro-organisms until the solid matter contained in the flowing sewage is dissolved

3. Same as #2 but with provision for an aeration section in connection with septic action which action prevents that of the other section.

4. Same as #1 but with provision for a filtering action to follow the aeration section.

5. In an apparatus for the purification of sewage, the combination of a septic tank, an outlet discharging above the bottom and below the normal water line of the tank, and an aerator between the outlet and the septic tank, and an aerator connected with said outlet.

6. In an apparatus for purifying sewage, the combination of drain or sewer with septic tank connected therewith and adapted to receive the contents thereof, a septic tank connected with said septic tank, and provided with an outlet discharging above the bottom and below the normal water line of said tank and near opposite the greater part of the width of the tank.

7. Same as #5 save that the outlet shall be a conduit having a continuous flow across the greater part of the width of the tank.

8. In an apparatus for the examination of sewage the combination of a settling tank having an outlet at considerable depth below the surface, a partition across the greater part of the width of the tank and disposed above the bottom and below the normal water-line of the tank, said tank having an inlet-opening through the bottom and adapted for emptying the effluent.

9. Same as claim 8 that the outlet is a conduit having a longitudinal slot extending the greater part of the width thereof, said slot communicating with the interior of the tank.

10. Same as #9 but with provision for [illegible] connected with said slotted pipe to diminish the communicating portion of the slot for discharging the effluent from said conduit.

11. In an apparatus for sewage examination, the combination of a settling tank an inlet disposed above the bottom of and below the normal water line thereof, and occupying the greater part of the width of said tank, and an outlet extending across the greater part of the width thereof and disposed above the bottom

and below the normal water level of the tank.

15. A provision for a slotted pipe or conduit disposed in the floor of said tank for the removal of the deposited matter, said floor sloping toward said pipe.

16. A provision for "perforated pipes disposed in said tank", and means for "delivering said water pressure into said pipes."

18. A provision for an out let for tank, "pipe across the greater part of the width of the tank and disposed ~~below~~ the normal lower level of the tank and an inlet above the inlet and below the normal water-line of the tank.

19. The combination of a septic tank, a pipe disposed at the bottom of said tank and provided with openings, and a series of pipes (12) disposed at bottom of said tank and adapted to deliver fluid under pressure into the tank, so as to agitate any deposited matter into said first-mentioned pipe.

20. Provisions for out let and inlet with "broadened mouths."

All of the claims are not given separately because those not stated here are merely combinations of those given, and containing in themselves no new points.

Claims of the Glover Patents.

In May 1882, Wm. A. L. Glover of Brockton, Mass. was granted a patent by the authorities at Washington controlling settling tanks. His claims are

1. In an apparatus for the disposal of sewage the combination of a series of tanks, a sewer main or pipe arranged to discharge sewage matter into the first tank of the series, from which the said matter flows successively through the other tanks, a building or enclosure over said tanks, having an inclined roof forming a flue having an opening at its lower end for the admission of external air, and a chimney connected to the upper end of said roof or flue, said chimney, flue, and opening causing a current of air to pass over the series of tanks to the chimney and carry with it all the gases and foul vapors arising from the matter in the tanks, as set forth.

2nd. The improved apparatus or building for the disposal of sewage, consisting of, first, a

central structure receiving a sewer main and provided with a ventilating flue or chimney and laterally radiating house connections each having a series of flues adapted to receive sewage matter from the central structure and an inclined rock or stone communicating with the central chimney and adapted to conduct the sewage matter from the sewer main into the central structure which is provided with means for shutting off the sewage from either of the house connections as set forth.

It might be said here that quite recently the courts refused to sustain the above patent claims which do not exist in the American Sewage Disposal Systems.

Claims of W. C. Bird and B. J. Hanley.

On Dec. 2nd 1913 a decision issued for Bird and Mr. Hanley and the claims are as follows: In a sewer disposal system, a sewer, a septic tank in the sewer having a baffle wall, a filter bed, a pipe leading from the septic tank to the filter bed, a pipe leading back to the sewer, a

and in connection with the septic basin; means of leading sludge from the basin to the sludge well; and means of flushing sludge-well substantially as specified.

2. In a septic sewer system: a septic basin divided into equal parts; a storm sewer; means of leading the sewage from the storm sewer to either of the parts of the septic basin; an outlet from the septic basin parts; under flow-walls in the septic basin; and manholes providing access to the septic basin parts; substantially as specified.

3. In a septic sewer system: a suitable septic basin; an inlet weir discharging into one side of the basin; a connection between the storm sewer and the inlet weir; an outlet weir leading from the opposite side of the basin; a connection between the outlet weir and the storm sewer; and under flow walls in said basin between the inlet weir and the outlet weir; substantially as specified.

4. In a septic sewer system: a storm sewer; a suitable septic basin; an inlet weir discharging into one side of the basin;

a connection between the storm-sewer and the inlet weir; a trap in said connection; an outlet weir leading from the opposite side of the basin; a connection between the outlet weir and the storm-sewer; a trap in said connection; and under-flow-walls in said basin between the inlet-weir and the outlet-weir substantially as shewed.

The Water for Hamilton

The city of Hamilton is a town of some 2000 inhabitants having a steam system of water. The Highlands of the country around Hamilton is a level land situated a little South-East from the business section, having left the East-Side a small stream near by. The dry months flow of this stream is from 3 to 4 cubic feet per second, and often in dry seasons is entirely free from flowing water in the bed. The high water flow is known to reach as much as 1000 cubic feet per second. The storage dam is built across the stream of about one and a half miles from Hamilton and consists of a rock fill dam about 30 feet high and 100 feet long. The reservoir is about 1 mile long and 1/2 mile wide and has a capacity of about 100 million gallons. The pumping plant is shown on page 23.

Computations

Amount of Sewage:-

Assuming the average daily water Consumption to be 80 gals per capita, and knowing that the total amount of sewage for flow is, for all practical purposes, the same as the daily water consumption, we can say that the total amount of sewage is 80 × 12,000 = 960,000 gals. per day. When 12,000 is the population. The actual readings show a flow at the outfall sewer of 480,000 gals per day in dry weather, but this amount is sometimes doubled in wet weather, due to seepage.

Size of Tank:-

Assuming the tank to be of ten-hour capacity, the capacity will be $^{10}/_{24} \times 960{,}000 = 300{,}000$ gals = 40,000 cubic feet. And again assuming that the tank is 8 feet deep, the area will be = $\frac{40000}{8} = 5{,}000$ sq ft. A tank 100' × 50' × 8' deep will be used, and it will have two compartments which can be operated separately. This arrangement

Give two tanks under one roof, each being 30' x 25' x 8 ft deep, the ratio of length to width being 4 to 3, which is advantageous.

Grit Chamber:-

From what has been done on tests etc in regard to the size of a grit chamber one can gather little. It seems best to the writer that the depth be about 5 feet, width 5 feet, and length about 15- 20 ft, this dimension being along the end of the tank. Cost of grit chamber is reduced by having it form a part of the Septic tank. The valve leading to the tank and to the by-pass are handily placed in this chamber. It might well be built semi-circular - the flat side of the chamber being the end of the tank. This chamber will be boarded over with planking.

Sludge Removal:-

The sludge which forms in the tank is ordinarily pumped from the bottom of tank to some near by sludge pit. Some pumps on force pumps being placed above the tank, and some suction pumps situated in like manner, but I think the ideal pump is a submerged rotary pump since it requires no priming, and if automatic power, such as a motor could be used, no superintendence would be necessary. Such a pump will be installed here, but it will be necessary to use a gas engine instead of a motor in this case, due to distant location of tank. The sump well is located near the entrance end of the tank and is circular in form, the radius being 5 feet. Connected to each tank connect the inlet to sludge layer, these trenches being 3.5 feet wide and four feet high. The pump should be a 6" centrifugal pump.

Thickness of Walls:-

(a) Side Walls of Tank:-

The formula used in this is $t = .25$ to $.4\sqrt{h}$ against embankment

When t = thickness and h = height.

Our walls will be ten ft. high hence

Thickness, $t = .3 \times 10 = 3$ ft. This of course is large for our case, as we have a roof which tends to prevent overturning both due to its weight and to the arching effect. Walls 15" on the sides and 18" on the ends will be large enough if bottom slightly, say 6" in 10 ft.

(b) Partition Wall of Tank:-

Try a wall 18" at top, 10 feet high and 3 ft at bottom with reinforcing rods as shown in figure 3 plate 6. To find amount of metal used.

Bending Moment = Resisting Moment

Bending Moment

$M_1 = 62.5 \times 4 \times 8 \times \frac{8}{3}$

$= 5330$ ft. lbs.

$= 64000$ in. lbs.

Where: 62.5 = weight of 1 cu. ft. of water

4 = distance from center of gravity to surface of water

A = Area in sq. ft.

8/3 = Moment arm in sq. ft.

Resisting Moment:-

$M_2 = .8 A' S d$

Where A' = area of steel in sq. ins.

S = allowable stress in steel in lbs. per. sq. in.

d = distance from reinforcement to compression edge.

$M_2 = .8 \times 33 \times A \times 12000$

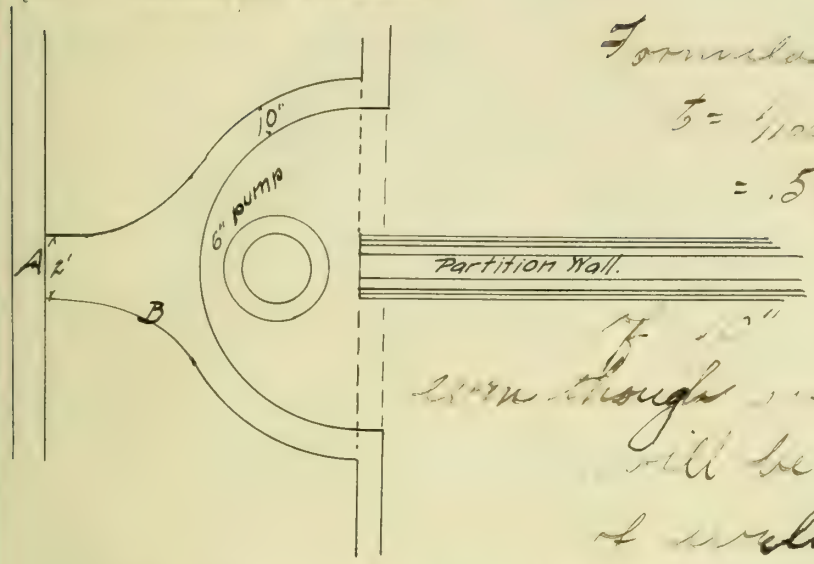
$= 316800 A$ lb. ins.

Equating M_1 and M_2

$316800 A = 64000$

$A = .202$ sq. in. for each lineal foot. Use ½" bars as the required amount of metal but two will be used per lineal ft.

A. Pump Room



Formula for free walls
$t = \frac{1}{100} ha = \frac{1}{100} \times 10 \times 5$
$= .5$ ft. = 6"

As third use 6" will be used, 2-6" troughs. Water pressure will be on both sides & will it once — & on either side at same time. Also the corners at A is enlarged so as to conform with corners of wall which hold for the partition wall. It will be made the same as the latter up to point B.

(2) Wall A-A fig 1. plate 5:

$t = .55h = .55 \times 10 = 5.5$ ft.

B-T since water pressure is same on both sides at all times, a very much smaller wall may be used. A 20 ft wall will be large enough, and no reinforcement need be used. The openings into the tank proper are shown on the accompanying sketch. They should be arched as shown so as to add to,

or rather not take away any of the strength of the wall. There are three such openings into each tank, thus giving ample chance for the sewage to enter the tank at a low velocity.

Baffles

A baffle shall be placed as shown over at entrance to reduce the velocity. It shall be made of 3" planking and be 15 feet long. One shall be placed in the middle of the tank, but since this is made to brace the side walls and structure as a whole, it will be made of concrete and held up by channels. The thickness is governed by the method of concrete construction, and a 10" wall or baffle-wall will be used here — i.e. a 10" channel will be used and the concrete built up inside.

Roofing:-

The roofing will be made of reinforced concrete, sloping from the center of tank as shown on plate The per cent of metal needed is found thus:-

Assuming that the I beams will be used to support the roofing, and taking a segment ten feet long (dist. between I-beams) one foot wide and four inches deep, when four inches is the distance from top of roofing to the reinforcing metal, or d.

Resisting Moment = Bending Moment

$$M = .8\,A\,S\,d = \tfrac{1}{8} W l.$$

$W = 800 + 200 = 1000$ #pr. ft. $\quad d = 4''$

$$\tfrac{8}{10} A \times 12000 \times 4 = \tfrac{1}{8} \times 1000 \times 10 \times 12$$

$$A = \frac{10 \times 1 \times 10}{8 \times 4 \times 1 \times 8}$$

$$= \frac{100}{256} = .39 \text{ sq. in}$$

When A = area of metal, sq. in.

S = stress in metal, lbs. per sq. in.

W = Wt. of segment, $5' \times 1' \times 4''$.

l = length " , $10'$.

Percent of metal = $\frac{.99}{.48} \times 100 = 8\frac{1}{2}\%$

This calls for .7 sq in of metal lengthwise of section so two ½" rods per foot will be used.

Estimate of Cost.

Excavation 2000 yds @ 25¢		$500.00
Concrete Construction 984 cu. yds. @ $8.00		7872.00
Piping		75 00
Six Inch Pumps		100 00
Gas Engine 10 H.P @ $15		150 00
Flooring,		50 00
20 I-Beams 6", 12.25#, 25', @ $.025 lb.		153 00
1 Channel, 12", 25#, 50' @ . .		31 25
2 Angles 6 x 6" x 3/4", 24' @ . .		34 45
3 Valves in Grit Chamber @ $8.00		24 00
Total		$8989 70
Extras and Contractors Profit 20%		1797 94
Grand Total		$10787 64

Conclusion.

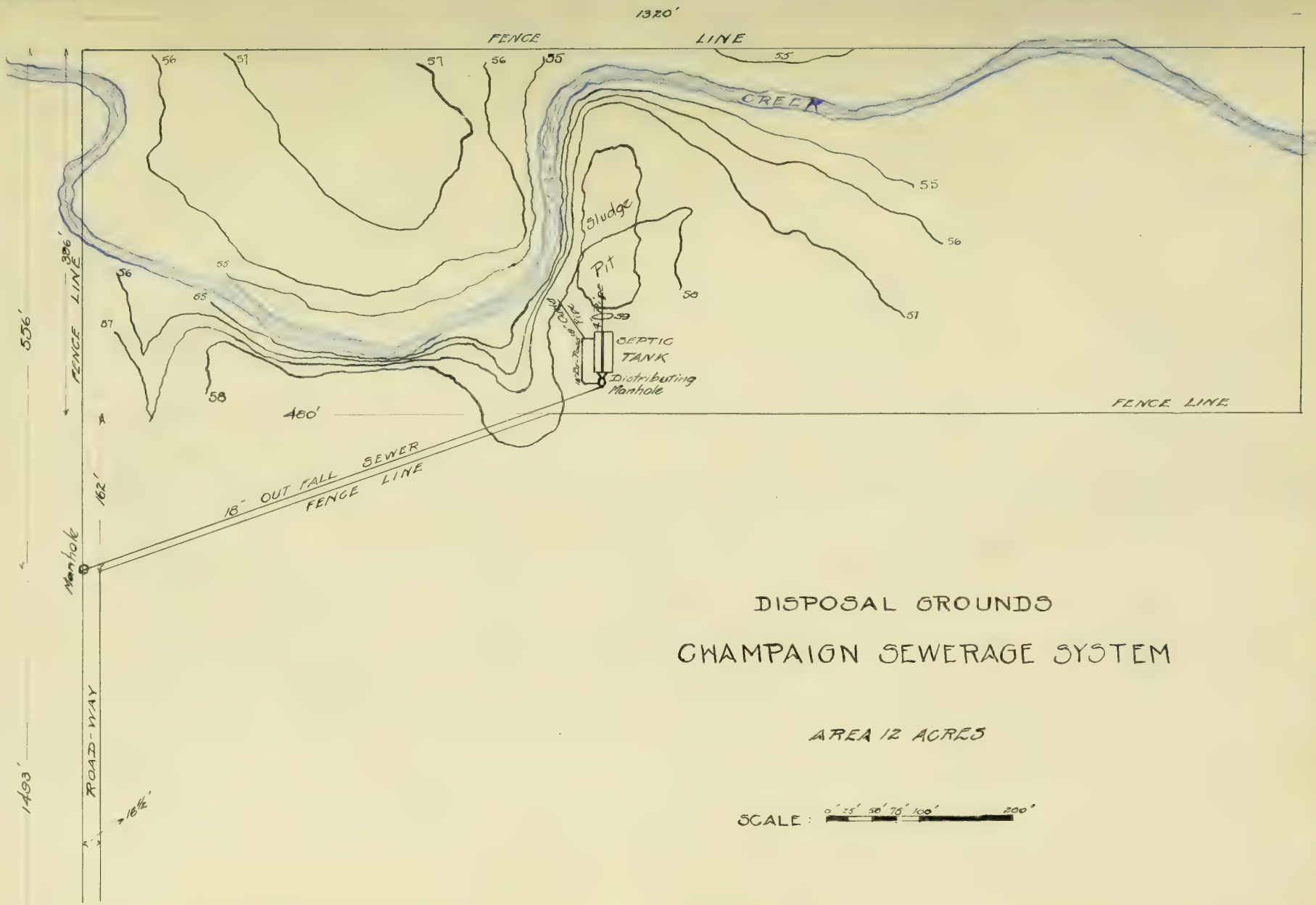
From what has been said concerning the efficiency of septic tanks in general it might be inferred, that it would be best to install some device for a sewerage system in towns, such as Champaign, but the tests which were made on the effluent from the Champaign tank show that, when the tank is not over-taxed, the primary process is complete enough to insure an effluent which, when discharged into the Salt Creek, will not cause further trouble. The tank installed here is large enough to take care of the total sewage of the city if the storm water sewage is excluded, as has heretofore been customary. It should be treated with care until the proper conditions of velocity, temperature etc. as noted in the discussions, are attained. The velocity should be such that the suspended matter will have time to settle, and this

tanks that it is immaterial how long the sewage remains, or rather how fast it is discharged, since the bacterial action continues on the suspended matter which remains in the tank.

In regard to the efficiency which may be expected, it is probable that about 80% is a conservative estimate. The efficiency depends so largely on the character of the sewage that it is not to be a matter in this matter. For, if the suspended matter is in finely divided particles when it reaches the tank, the efficiency is said to be lower than if the particles are larger, due to the fact that the latter particles settle so much more rapidly. The reduction of the suspended matter in the Champaign tanks, as shown by the reduction in oxygen consumed, nitrogen and albuminoid ammonia and total organic nitrogen, averages 74%. This is extremely high and it is not safe to look for any such results in most cases. The

reduction in organic matter in section should be from 15% to 20% in ordinary weather with a humidity of 25% to 30% in warm weather.

PLATE 1.



DISPOSAL GROUNDS

CHAMPAIGN SEWERAGE SYSTEM

AREA 12 ACRES

SCALE: 0' 25' 50' 75' 100' 200'

PLAN
OF
SEPTIC TANK.

SCALE

5' 10' 15' 20' 30' 40' 50'

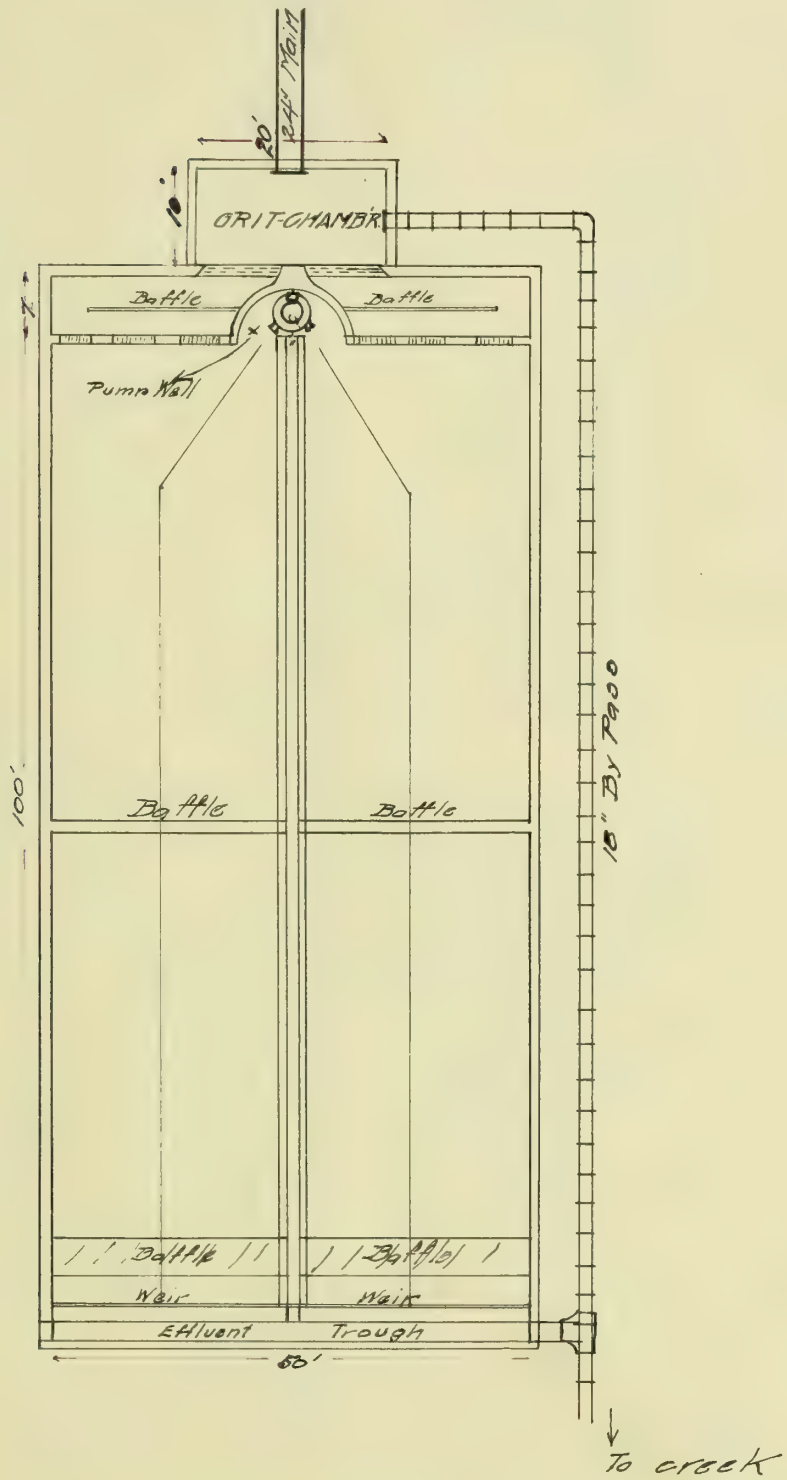


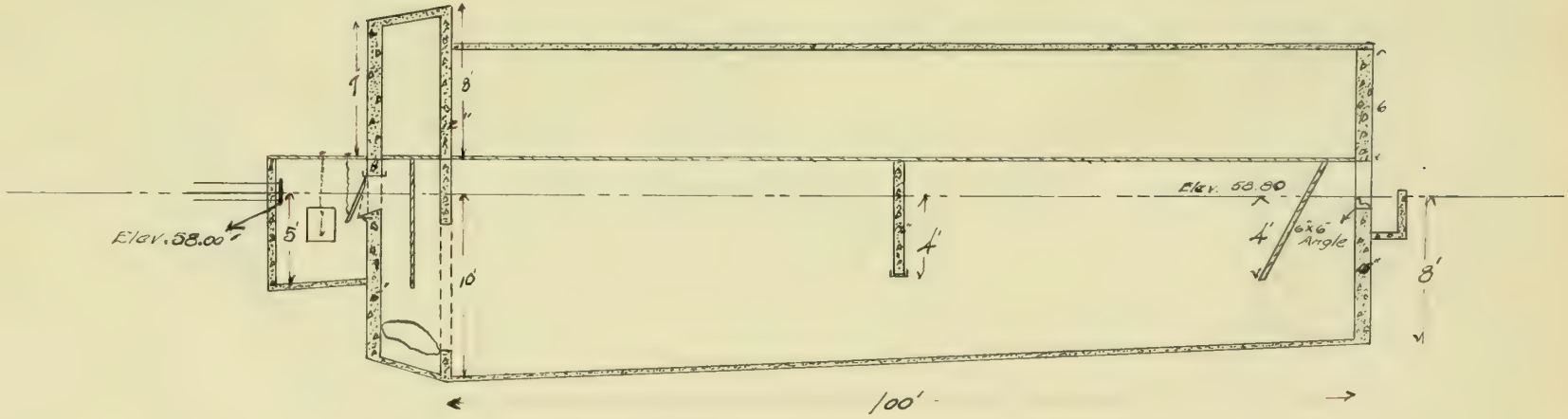
PLATE 2.

PLATE 3.

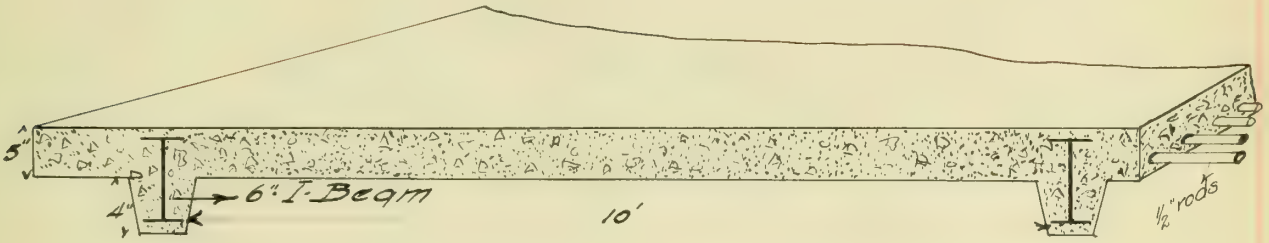
SECTION THROUGH TANK.

SCALE IN FEET

0' 5' 10 20 30' 40' 50'



ROOFING.



END VIEW.

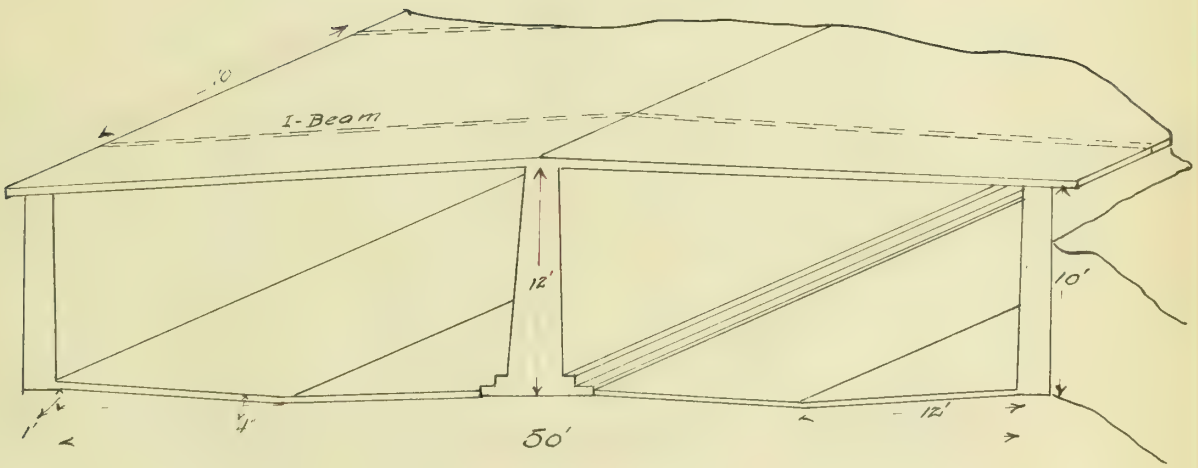
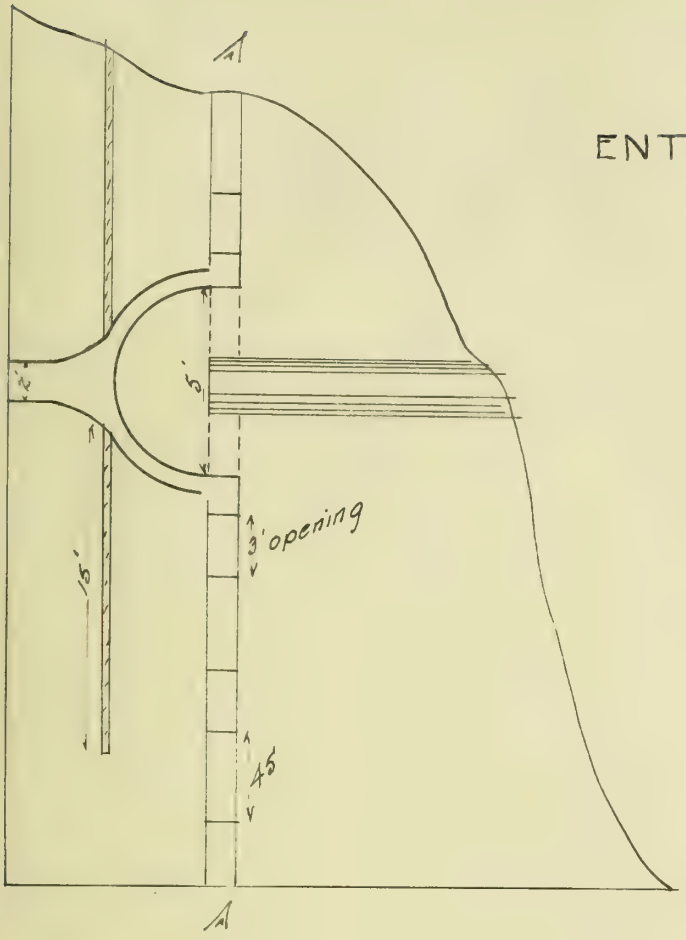
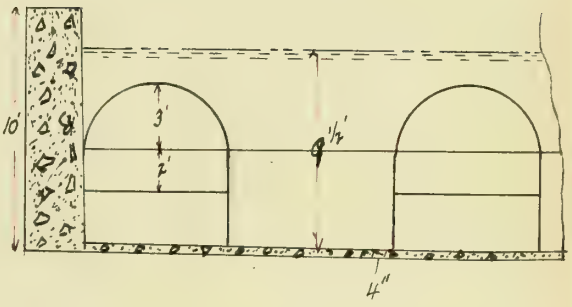


PLATE 4.

ENTRANCE WALL
AND
PUMP WELL





PARTITION WALL.

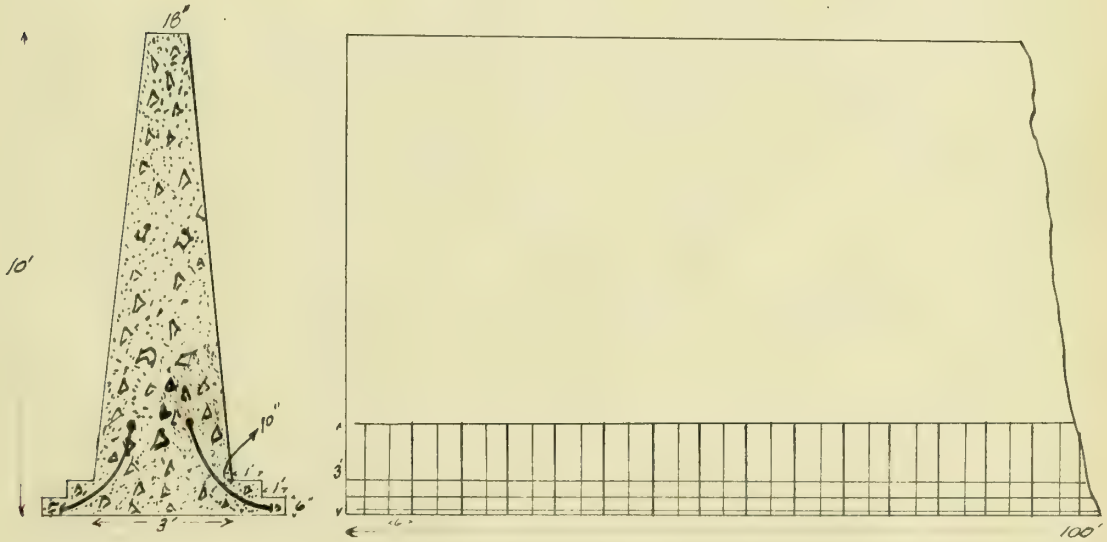
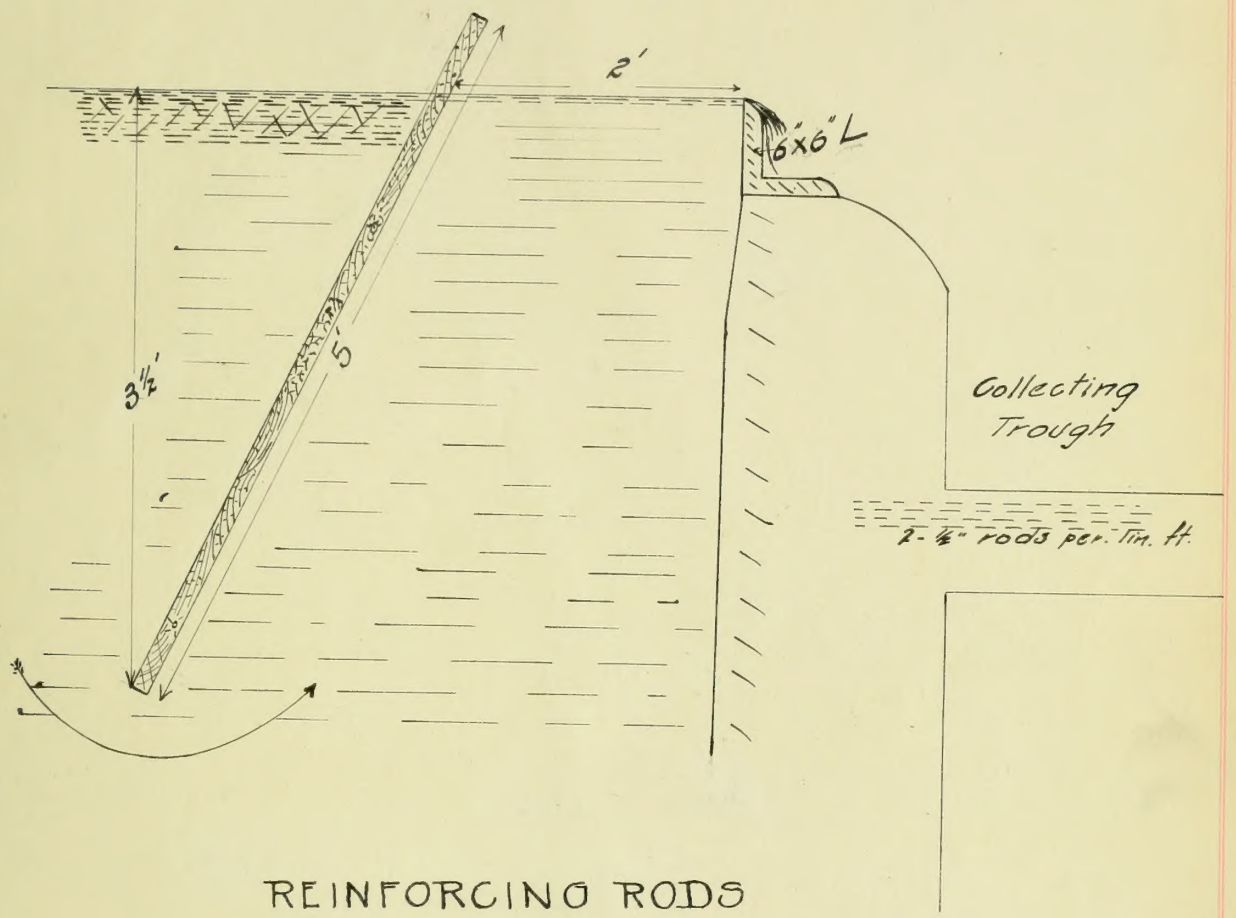


PLATE 5.

EFFLUENT COLLECTOR



REINFORCING RODS IN PARTITION WALL

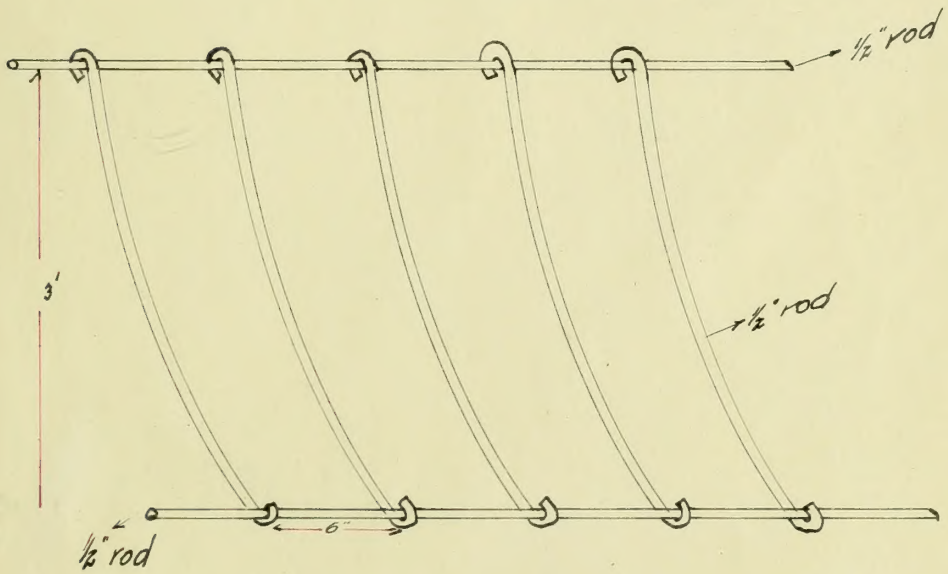


PLATE 6.

UNIVERSITY OF ILLINOIS-URBANA
3 0112 082195063